



## IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:  
Jie Liu et al.

Serial No.: 10/662,083

Filed: September 15, 2003

For: COMPOUND ELECTRODES FOR  
ELECTRONIC DEVICES

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Group Art Unit: 2826

Examiner: Fazli Erdem

Atty. Docket: 132096-1/YOD  
GERD:0480

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

CERTIFICATE OF MAILING 37 C.F.R. 1.8	
I hereby certify that this correspondence is being deposited with the U.S. Postal Service with sufficient postage as First Class Mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, on the date below:	
3/28/2007 Date	Lynda Howell Lynda Howell

**DECLARATION OF JIE LIU**  
**UNDER 37 C.F.R. §1.131**

I, Jie Liu, hereby declare as follows:

1. My name is Jie Liu and I currently reside in New York; my current address is 1265 Sagemont Ct., Niskayuna, New York 12309.
2. I am a named co-inventor on the present patent application, Serial No. 10/662,083.

Serial no. 10/909,611

Affidavit of Jie Liu

Page 2

3. At the time the invention claimed in the referenced application was made, I was employed by General Electric Company at its Corporate Research and Development facility in Niskayuna, New York, as a Material Scientist.

4. My co-inventors and I conceived of and actually reduced to practice the subject matter disclosed and claimed in the above-referenced application prior to April 23, 2003, the priority date of U.S. Patent Application Publication No. 2004/0245917. This conception and reduction to practice are evidenced by the presentation "Disclosure Letter Outline" dated prior to April 23, 2003, a true and correct redacted copy of which is attached hereto as Exhibit A.

5. In accordance with the practices of my employer, General Electric Company, at the time of this invention, the Disclosure Letter Outline was completed to begin the patent application process. I provided the Disclosure Letter Outline and supporting documents to my laboratory manager Mr. Steven Duclos.

6. From the date of submission of the Disclosure Letter Outline, the invention and patent application preparation processes followed their normal courses, with due diligence on the part of all involved to draft the present application and to place the application on file on September 15, 2003.

I declare further that all statements made herein are of my own knowledge are true and that all statements made on information and belief are believed to be true, and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. §1001, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

Dated:

3/16/2007

By:

  
Jie Liu

# EXHIBIT A

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GE Confidential & Proprietary Information.  
This invention is being prepared for submission  
to the GE Patent And Legal Operation. Attorney  
work product may be contained herein.

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## GE Patent Disclosure Letter System

### DOCKET NUMBER

31359

### DOCKET DATE

[REDACTED]

### TITLE OF INVENTION

Metal fluoride and metal bi-layer as an electron injection  
electrode

### GE TECHNOLOGY AREA(S)

[REDACTED]

### Keywords:

[REDACTED]

[REDACTED]

### Keywords:

[REDACTED]

[REDACTED]

[REDACTED]

### PROJECT NAME

[REDACTED]

### PROJECT NUMBER

[REDACTED]

[REDACTED]

**PROJECT LEADER****BUSINESS OR ORG. CONTACT INFORMATION****NAME****PHONE NUMBER**

**Was this invention first conceived or reduced to practice in the performance of work under a contract between GE and another non-government third party? NO**

**Date Invention Conceived :** [REDACTED]

**Circumstances Invention Conceived i.e., described in patent notebook (include page #), technical report, letter, discussed in meeting minutes, etc.**

[REDACTED] - initial ideas, described in notebook on page #13;

[REDACTED] - Discussion with [REDACTED] in lab [REDACTED]

Discussion with [REDACTED] in office [REDACTED] - Recieved Auger Electron Spectroscopy results from [REDACTED]

[REDACTED] - First batch devices (I-V measurement) [REDACTED]

- Second batch devices (measured with a curve tracer with [REDACTED])

**Was this invention first conceived or reduced to practice in the performance of work under a US Government contract? NO**

**ABSTRACT OF THE INVENTION**

**Please write a brief explanation of the invention (Limit to 350 words)**

A composite cathode based on metal(A) fluoride and metal(B) has been developed, where metal (A) and metal (B) can be either same or different. A metal(A) fluoride/metal (B) bi-layer, where the metal(B) is in direct contact with the emissive layer, can be used as an efficient electron injection electrode in organic/polymer light-emitting diodes

**BACKGROUND OF THE INVENTION**

**Please describe the problem or requirement addressed by your invention.**

A remarkable efficiency enhancement has been achieved by introducing a thin metal fluorides layer between the aluminum cathode and the emissive layer of both organic-based light-emitting diodes (OLEDs) and polymer-based light-emitting diodes (PLEDs). [REDACTED]

[REDACTED] Since then, other metal

fluorides, such as CsF [REDACTED], BaF [REDACTED] and NaF [REDACTED] have been successfully employed in both OLEDs and PLEDs. [REDACTED] other metals, such as calcium [REDACTED], in the place of Al. In the works reported earlier, the metal fluoride layer is in direct contact with the organic/polymer emissive layer, as shown in Figure 1. The deposition of overlying Al layer causes damages of the emissive layer, which lowers the quantum efficiency. In addition, thermal evaporation of metal fluoride followed by Al onto the emissive layer under high vacuum is not desirable for mass production, such as roll-to-roll process.

**How has this problem or requirement been addressed before?**

n/a

**Is this disclosure letter related to any GE disclosure letters, patent applications or issued patents?**

**Have you completed a prior art search?** [REDACTED]

**Please list any relevant literature or patents of which you are aware.**

#### **DETAILED DESCRIPTION OF THE INVENTION**

**How does your invention work?**

Deposit a thin layer of metal(A) fluoride, such as NaF, followed by a thin layer of metal(B), such as aluminum, onto an underlying electrode, which can be metals, such as silver, or metal oxide, such as indium tin oxide, or other conductive medium, such as conducting polymers or conductive epoxy. The finished part, i.e. underlying electrode/metal(A) fluoride/metal(B), serves as the cathode. Then a layer of emissive materials, or a layer of electron transport material, is deposited onto the metal(B) surface.

**Describe the important features of your invention and explain how to use the invention to solve the problems described above.**

First, the above-mentioned metal fluoride/metal bi-layer structure can be used as an efficient electron injection cathode, which is crucial for both small-organic-molecule-based and polymer-based light-emitting devices. Second depositing emissive materials onto metal(B), such as Al, will dramatically reduce the possible damages caused by the deposition of metal(B), such as Al, onto the emissive materials. Third, the new cathode allows us to engineer and optimize the cathode interfaces independently, which is more

mass production, such as roll-to-roll process compatible. Fourth, fully transparent OLEDs and PLEDs can be fabricated by depositing metal(A) fluoride/metal(B) onto a transparent electrode, such as indium tin oxide, and using the existing anode electrode, typically indium tin oxide. An additional advantage of this invention is that the entire structure can be sealed to make a readily activated electrode. For example by putting a metal or polymer overlayer atop the substrate/NaF/Al structure that serves to isolate the cathode from the ambient, but can selectively removed via a low temperature electro-chemical or evaporative process. Thus the cathode can be preformed via vapor deposition and then introduced into a non-vacuum roll-to-roll process, activated by selective overlayer removal and then used in organic devices.

**What advantages are provided by your invention?**

See above

**Has your invention been reduced to practice? YES**

Date: [REDACTED]

**Briefly describe any efforts to make a prototype of your invention or to test your invention. Additionally, summarize the results of any related experiments and testing and highlight any results of particular significance.**

On [REDACTED], two devices, i.e. Glass/Ag (80nm)/NaF(4nm)/Al(8nm)/LEP/NaF(4nm)/Al(100nm) were fabricated. Their current-voltage characteristics were measured. Experimental data show that at high voltages, the currents under reverse bias is less than that under forward bias only by a factor less than 3, which indicates that the NaF/Al/(polymer) electrode has comparable efficiency of electron injection as the (polymer)/NaF/Al electrode. On [REDACTED], four devices with the same structure were fabricated and tested with a curve tracer. Current-voltage curves (see attachments) clearly confirmed that the NaF/Al/(polymer) electrode can be equally efficient, in terms of electron injection, compared to the (polymer)/NaF/Al electrode.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

**Please describe the significance of any pictures, drawings, graphs, diagrams, structures or figures and the type of picture along with the specific view or application to the invention.**

Figure 1. Typical device structure as reported, where the metal fluoride is in direct contact with the electron-transport layer or the emissive layer. Figure 2. Structure of devices fabricated in this invention - Glass/Ag/NaF/Al/LEP/NaF/Al.

Figure 3. Current-voltage curves of one pixel as fabricated (A) and after (B) 2 mins and (C) 4mins continuous bias at 10 volts. Figure 4. Current -voltage curves of one pixel operated in AC and DC modes. (A) AC (60Hz) mode, (B) DC mode, forward bias (defined as Ag is positively biased, while the top Al negatively biased), (C) DC mode, reverse bias (Ag is negatively biased, while the top Al positively biased), and (D) back to AC (60Hz) mode

### CLAIMED INVENTION

**Please identify novel aspects that should be protected within this disclosure letter.**

1. Metal(A) fluoride/metal(B) (where the metal(B) is in direct contact with the emissive layer or the electron-transport layer) as a charge injection electrode in electronic devices, such as small-organic-molecule-based or polymer-based light-emitting devices; 2. A transparent cathode material; 3. The method of fabricating transparent small-organic-molecule-based or polymer-based light-emitting devices. 4. Sealing the metal cathode layer with an additional layer that can be selectively removed.

### ATTACHED FILES

Attachment for disclosure j LIU.doc

DUTY OF DISCLOSURE		
a.	Have steps been taken to put into use, either outside GE or in our own operations?	<input type="checkbox"/>
b.	Has the invention or a product embodying or using it been sold or offered for sale?	<input type="checkbox"/>
c.	If the invention pertains to a process, have any steps been taken to employ the process commercially (e.g., for product production)?	<input type="checkbox"/>
d.	Has the invention been described in an electronic or printed publication?	<input type="checkbox"/>
e.	Has the invention been described to persons who are not employees of GE?	<input type="checkbox"/>
f.	Are there results available of a prior art search pertaining to this invention?	<input type="checkbox"/>
g.	Has anyone else associated with the project within GE (marketing, sales, sourcing, etc.) disclosed the invention or offered the invention for sale?	<input type="checkbox"/>
h.	If you answered Questions a-g as "NO", is any	<input type="checkbox"/>

use, sale, publication, or disclosure of the invention now contemplated?

## CO-INVENTORS

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*Jie Liu	1265 Sagemont CT Niskayuna, NY zip - 12309	[REDACTED]	[REDACTED]

\*Lead co-inventor

Primary / Financing Business (or Advanced Technology Program) : [REDACTED]

Primary / Financing Component : [REDACTED]

Associated Lab/Program : [REDACTED]

Assigned Attorney : [REDACTED]